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ABSTRACT

The purpose of this study--which was a part of the Flexible Learning Environment project at the University School of Nova University in Florida--was to determine if there was a difference in learning to solve mathematics word problems between groups using computer assisted instruction and groups taught by teachers. Fifth-grade students (N=31) were divided into four groups (two teacher-taught groups and two computer-taught groups) for the 4-week experiment, in which instruction in word problems was given every day. Subjects in all groups were given a test before the beginning of the experiment. An independent t-test found that the difference between the pretest means was not significant. At the end of the experiment all groups took the same test as they had taken before the experiment. An independent t-test found that the difference between the post-test means was not significant. It was concluded that computer assisted instruction could be used as an alternative to conventional methods of teaching mathematics word problems. The test used as the pre- and posttest is appended. (15 references) (GL)

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Helping Students to Solve Word Math Problems: CAI as an Alternative Method of Instruction

by

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Informatics in Elementary Education

ABSTRACT

Helping Students to Solve Word Math Problems: CAI as an Alternative Method of Instruction

Viteli, Jarmo J., 1989.

Descriptors: Computer Assisted Instruction/Problem Solving/Solving Word Math Problems/Elementary Education.

The purpose of this study was to determine if there was a difference in learning to solve word math problems between groups using computer-assisted instruction (CAI), and groups taught by teachers. Fifth- grade students were divided into four groups; two teacher taught groups and two computer taught groups.

The duration of the experiment was 4 weeks. Every day the computer groups worked with computers solving word math problems while the teacher groups worked with a teacher helping the students learn to solve the same kind of word math problems.

Subjects in all groups were given a test before the beginning of the experiment. An independent t-test found that the difference between the pretest means was not significant (.05 level). At the end of experiment all groups took the same test as they had taken before the experiment. An independent t-test found that the difference between the post-test means was not significant (.05 level). It was concluded that CAI could be used as an alternative for conventional methods of teaching word math problems.

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STATEMENT OF THE PROBLEM

The present study was a part of the Flexible Learning Environment project at the University School of Nova University. The objective of the project is to create a learning environment that meets the needs of each student. A common observation is that word math problems are one of the most difficult areas in the fifth grade math curriculum. Dr. James Smith, who has worked with the University School as a consultant, suggested the writer try computer-assisted instruction to improve students' ability to solve word math problems. Hence, the present study was undertaken.

The purpose of this study was to determine if fifth grade students would learn to solve word math problems more effectively if they were taught by CAI as opposed to by a teacher. Students selected for the study had poor mathematical skills. The sample included 31 students, 15 boys and 16 girls.

The duration of the experiment was 4 weeks. Students worked in their groups (computer and teacher taught) each day for 25 minutes. A pretest was given to establish that the computer taught and teacher taught groups were not different in their math skills before the experiment. Students were given a post-test, to determine the effectiveness of using CAI over the traditional teacher instruction.

There are four groups in the fifth grade at the University School of Nova University: (a) Circle = lowest mathematical skills, (b) Triangle = second lowest mathematical skills, (c) Diamond = second highest mathematical skills, (d) Pentagon = highest mathematical skills

The circles and the triangles were selected for participants in this study. Students had already been divided into two subgroups according to alphabetical order. Half the students in each group served as the experimental group (CAI), and the other half as the control group (Teacher instruction). Figure 1 shows the design of the study.

Figure 1. Design of the present study

GROUP		GROUP	
"Circles"		"Triangles"	
PRETEST			
computer	teacher	computer	teacher
E X P E R I M E N T D U R A T I O N (four weeks 25 minutes every day)			
POST-TEST			

The questions of interest to this study were as follows:

1. Is there a difference between the computer-taught group and the teacher-taught group in solving word math problems for the circle group?

2. Is there a difference between the computer-taught group and the teacher-taught group in solving word math problems for the triangle group?

RESEARCH HYPOTHESIS

Computer-taught groups will perform significantly better on the post-test than the teacher-taught groups. An alpha level of .05 was to be used to test the hypothesis for each of the two groups (circles and triangles).

BACKGROUND AND SIGNIFICANCE OF THE STUDY

Problem-Solving Strategies

In general problem-solving strategies do not guarantee solutions, rather they serve as guides in the problem-solving process (Mayer, 1983). For example, in algebra, a useful strategy to solve equations is the isolate strategy, in which the solver isolates the target variable on the left side of the equation and places all the numbers on the right side of the equation (Mayer 1982). The application of this is restricted to some specific domains. There are also more general strategies that can be applied across a variety of domains. Problem decomposition, or breaking the problem into subproblems, is a useful general strategy in problems of design in architectural problems (Simon, 1973) and the design of software (Jeffries, Turner, Polson, & Atwood, 1981).

A general strategy used by GPS (General Problem Solver; Newell & Simon, 1972) is means-ends analysis, which involves reducing the difference between the current state and the goal of the problem by applying appropriate problem-solving operators. This strategy is useful whenever the initial and goal states of a problem are fairly well specified. An everyday example of means-ends analysis is the goal of cooking a Chinese dinner, given a stove but no proper ingredients. The cook seeks to reduce the difference between the current and goal states by applying an operator (i.e., by going to store and buying food). Means-ends analysis may be applied recursively until the goal is reached e.g., getting money to enable food purchase (Gick & Holyoak, 1979).

Problem-Solving Process

Information-processing theories of problem solving (Greeno 1978; Simon, 1978) emphasize two important processes: Generation of a problem representation or problem space (the problem solver's view of the problem), and a solution process that involves a search through the problem space.

Figure 2. Schematic diagram of the problem-solving process (Gick 1986)

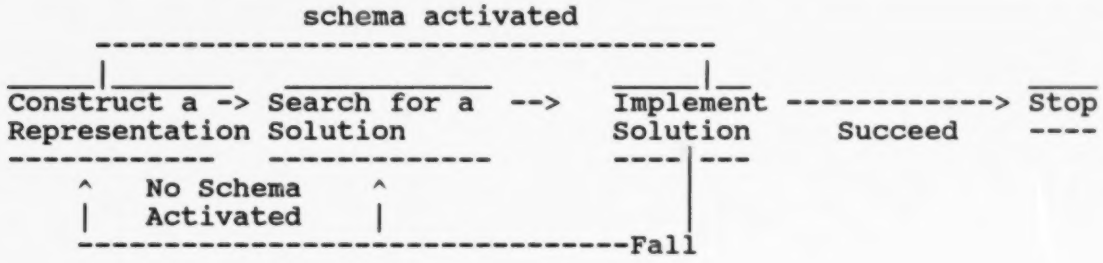

Figure 2 presents a schematic diagram of the problem solving process. Following the first stage of the construction of a problem representation, the problem solver searches for a solution to the problem and implements it. If the solution is successful, the task is over. If it fails, the solver backtracks to an earlier stage and attempts to redefine the problem or use another method to solve it, depending on the nature of the failure (Gick 1986).

CAI For Effective Mathematics Instruction

During the last decade there has been a lot of discussion concerning the benefits of using CAI (Computer-Aided Instruction) in teaching. As early as 1972 Hatfield (1972:9) reported that "writing and using computer programs related to selected mathematical content positively affects performance."

Dusseldorp, Edwards, Norton, Taylor, and Weiss (1975: 147) reviewed many studies and found that:

1. Normal instruction supplemented by CAI was more effective.
2. When CAI was substituted for traditional instructional no clear advantage for either strategy was apparent (based on 20 studies).
3. Drill and practice, tutoring, problem solving, and simulation have been shown to be more effective with CAI than with traditional instruction in some studies but no more effective in others (based on 32 studies).

4. Students took less time to learn through CAI than other instructional methods.
5. Retention of learning may not be as strong through CAI as other methods (based on 3 studies).
6. CAI drill and practice may be more effective for low ability students than for average and above students.

Bangert, Kulik and Williams (1983: 19-78) noted the following results based on the evaluation of 51 studies.

1. Compared to conventional instruction, CAI raised final examination scores .32 standard deviations, or from the 50th to the 63rd percentile.
2. Retention on follow-up exams given several months after the completion of instruction favored the CAI classes by .17 standard deviations.
3. Student attitudes toward the subject matter, computers, and the quality of instruction were generally very positive with CAI.
4. Students using CAI took substantially less time to learn the identified components.

Roblyer (1985) reviewed 12 studies on instructional computing published between 1972 and 1985 and noted the following:
1. Supplemental computer-based instruction showed greater learning effects than replacement CAI.
2. Use of CAI resulted in a significant reduction in instructional time and in more favorable attitudes toward computers.
3. Highest achievement effects were found in the elementary grades with mathematics CAI, showing more gains made than in reading and language arts.
4. Younger and lower ability students seemed to learn better from drill and practice CAI than tutorial.
5. In general, computer-based instruction resulted in small to moderate effects on increased achievement, but these effects were often smaller than those from studies of other non-computer based strategies.

Niemiec and Wahlberg (1987) examined 16 studies of CAI at all levels of implementation. The analyses showed that the typical effect of CAI is to raise outcome measures moderately by .42 standard deviation units.

This literature review does show that CAI can be highly effective in a variety of areas. However, there are studies that do not provide any evidence that CAI is more effective than traditional modes of instruction. In evaluating the studies that do not show

effectiveness, it is important to consider that CAI is dependent upon the software available for instruction. Stevens and Sybouts (1982) noted that software must be selected carefully on the basis of designed criteria. The computer can be misused just as any complex teaching aid. If properly employed, however, it can serve as an instructional tool to provide either programmed instruction or remedial instruction in many content areas.

DEFINITION OF TERMS

- **Word math problem** is a mathematical problem which includes text and numbers.
- **Solving a word math problem** means that the student first picks the right numbers, selects the right operation (addition, subtraction, multiplication or division), and then gets the correct solution.
- **Computer groups** mean those students who are working with the computer, when they are doing word math problem exercises.
- **Computer-Assisted Instruction (CAI)** refers to the teaching and learning that occurs during interaction between the software program and the students using a computer.
- **Software** means a set of computer programs, procedures and related materials designed to solve a specific application.
- **Microcomputer** means a computer whose Central Processing Unit (CPU) consists of a single integrated circuit known as a microprocessor.
- **Conventional method of instruction** refers to the teaching and learning that occurs during interaction between the teacher and students.

LIMITATIONS OF THE STUDY

The school, where this research was conducted, is a private elementary school in Davie, Florida. Thus, generalization will be limited only to the students selected.

It was not possible to randomly assign students to the experimental group and the control group.

BASIC ASSUMPTIONS

The basic assumption is that students in group 1 and group 2 are reasonably homogeneous in terms of their mathematical skills.

PROCEDURES FOR COLLECTING DATA

Before the beginning of the experiment all students were given a test (Appendix A) to see how much they knew at that point. At the end of the experiment students were given the same test to see how much they had learned.

In this study a single computer laboratory with 8 Apple II and 4 Tandy 1000 SX personal computers were used by the experimental group. The students worked for 25 minutes every day on word math problems with computers. The conventional groups worked with the teacher. During CAI, students worked individually, however, the laboratory supervisor was present all the time.

The students were given a general strategy to facilitate their starting to solve word problems:

1. Read the word problem
2. Find all the numbers in the problem.
3. Choose the operation.
   (+,-,*,/)
4. Choose the numbers needed for the problem.
5. Work the problem.

The test (Appendix A) included 16 assignments; 4 subtraction, 4 addition, 4 division, and 4 multiplication. The last assignments were more difficult than the first ones.

RESULTS

Pretest means were first compared to see if the computer-taught groups and the teacher-taught groups had similar math skills (word problem) before the experiment was initiated. An independent sample t-test showed that the pretest means for the CAI and the teacher groups were not significantly different at the analysis compared the post-test means for the CAI and the teacher-taught groups using a t-test for independent samples. This analysis showed that the two groups did not perform significantly different (.05 level) from each other (see table 2).

Table 1

Pretest Means, Standard Deviations and Results of the t-test

	CAI	Teacher taught
Circles		
M	58.50	58.00
SD	19.53	11.39
n	6	7
t = .06	p > .10	df = 11
Triangles		
M	73.78	72.67
SD	12.58	9.39
n	9	9
t = .213	p > .10	df = 16

Table 2

Post-test means, Standard Deviations and Results of the t-test

	CAI	Teacher taught
Circles		
M	70.67	63.00
SD	26.61	14.17
n	6	7
t = .66	p > .10	df = 11
Triangles		
M	87.00	79.67
Sd	10.99	19.15
n	9	9
t = 1.00	p > .10	df = 16

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

The results of the present study showed that CAI was no more effective than teachers in teaching fifth graders to solve word math problems. However, an examination of the post-test scores vis-a-vis pretest scores suggests that learning occurred both in the

computer-taught groups and the teacher-taught groups. Thus, it seems the CAI can be used, at least, as a supplemental aid. Perhaps teachers can use CAI for easier problems and engage in face-to-face instruction only for difficult concepts that require a great deal of explanation.

There is clearly a need to spend time with students to ensure that they understand what they have to do and what kind of mistakes they are making. Teachers need to pay careful attention to errors other than simple ones and having students repeat the problems. This is summarized by Roberts (1980) as follows:

> The samples of student strategies exhibited here strongly suggest that a remedial program in arithmetic must take into account more than the bare facts of the pupil's ability to "do subtraction". By analyzing the child's method or even his lack of method when confronted with a problem, the teacher will be in a better position to choose specific measures designed to help youngster overcome his difficulties and raise the level of competence.(p.446)

In conclusion, future studies are required to be carried out in laboratory settings in which rigorous control is possible. Without doubt, the future of CAI looks very challenging and promising.

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APPENDIX A

YOUR NAME _____

WORD PROBLEM QUIZ

DIRECTIONS: INDICATE OPERATION USED AND MARK CORRECT ANSWER.

G O O D L U C K !

---

1. A satellite is traveling around Earth at a speed of 17,641 miles per hour. If it travels any slower, it will fall back to Earth. How far will the satellite travel in 16 hours?
a) 17567

b) 17625

c) 282,256

d) 282,266

---

2. During a four-hour period, a space station is hit by 840 small meteors. Luckily, they are all very small, so the station is not damaged. Wnat is the <u>average</u> number of meteors that hit the space station each hour?
a) 844

b) 21

c) 836

d) 210

---

3. It takes a rocket 341 days to travel from Earth to Mars. If that same rocket then continues to Jupiter, that portion of the trip will take 814 days. How long will it take the rocket to get all the way from Earth to Jupiter?
a) 73

b) 1156

c) 1155

d) 210

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4. The Americans landed on the Moon in 1969. This was 426 years after Copernicus first published his idea that the Earth goes around the Sun. In what year did Copernicus publish his idea?
a) 1543

b) 1544

c) 2395

d) 1443

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5. Billy's family plans to spend Spring vacation in the Bahamas. They will fly to Nassau and rent a hotel room. If the hotel room costs $ 390 for 6 nights, how much does the room cost each night?
a) 65.00

b) .65

c) 6.50

d) 23.40

---

6. Bill tries the golf course during his first day in Nassau. He hits his first drive 234 yards and his next shot 178 yards. What is the total distance he covered with both shots?
a) 400 yds

b) 212 yds

c) 412 yds

d) 56 yds

---

7. Jennifer, Bill's younger sister, signs up for scuba diving lessons. She has to pay $ 12 a lesson. If she has time for 12 lessons, how much will she have to pay in all?
a) $ 444

b) $ 424

c) $ 24

d) $ 144

---

8. Billy's dad wants to charter a fishing boat to try some deep-sea fishing. The boat costs $ 250 day. If Bill's dad has $ 325 in spending money, how much will he have left if he charters the boat for a day?
a) $ 35

b) $ 75

c) $ 575

d) $ 80

---

9. Mr. Morgan pays a painter $ 504 to paint his house. Mr. Morgan buys the paint, which costs $ 168. If the painter works 42 hours on the house, how much does he earn per hour?
a) $ 12

b) $ 4

c) $ 40.00

d) $ 70.56

---

10. Pam's father owns a real-estate company. Last year the company sold 271 houses with an average value of $ 89,000. This year he sold 148 houses. How many more houses did he sell last year than this year?
a) 123

b) 419

c) 10,000

d) 133

---

11. An airline pilot flies 1,900 miles every day she works. Her salary is $ 3500 a month. How far will the pilot fly in a month with 21 working days?
a) 5700 mi.

b) 39,900 mi.

c) 95 mi.

d) 40,000 mi.

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12. The Tightwad Construction Company has 6,408 employees working on a dam project. If Tightwad is forced to hire 773 more men and 314 more women, how many new employees does Tightwad hire?
a) 459

b) 1087

c) 5635

d) 6094

---

13. The diameter of Earth is 7,918 miles. The diameter of Jupiter is 86,900 miles. If the Sun is one hundred and eight times the diameter of the Earth, what is the Sun's diameter?

a) 9,385,200

b) 71,262

c) 856,144

d) 855,144

---

14. If you weigh one hundred pounds on Earth, you would weigh thirty-six pounds on Mars and 264 pounds on Jupiter. How much more would you weigh on Jupiter than on Mars?
a) 232 lbs.

b) 296 lbs.

c) 164 lbs.

d) 64 lbs.

---

15. Janet sleeps out in the back yard with two of her friends. They watch the night sky and see an average of thirteen shooting stars (meteorites) each hour. If the three girls see 52 shooting stars, how many hours do they watch?
a) 4 hrs.

b) 676 hrs.

c) 39 hrs.

d) 65 hrs.

****
BONUS
****

16. Two alien flying saucers attack the Earth. One saucer has a diameter of 400 meters and carries 1,389 giant smelly monsters. The second ship has a diameter of 325 meters and carries 946 monsters. How many monsters did the aliens bring to attack the Earth?